Spin Polarized Photoemission Study of Half Metallic Magnetite Films

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Many materials such as Heusler alloys, manganites, Metallic oxides and pervoskites have been predicted theoretically to be half metallic, i.e. displaying a co-existence of metallic character for one electron spin population and insulating character for the other, and hence 100% spin polarization at the Fermi level (figure 1). Such materials hold out the possibility for use in the data storage and semi-conductor industries as pure spin sources in spintronic devices. However, despite extensive study of such candidate materials, remarkably little truly definitive experimental evidence for half-metallic character has emerged, and what evidence has emerged has frequently been somewhat contradictory. One technique that can potentially yield a definitive answer to this question is spin-polarized photoemission, as this allows us to directly probe the majority and minority density of states in the valence band and near Fermi edge region. It is from this technique that the best evidence for half metallic character to date as emerged [1]. However such experiments are frequently hampered by the difficulty in producing clean stoichiometric surfaces with a polarization that is truly representative of that of the bulk material.

We have used the spin-resolving photoelectron spectrometer of the Spectromicroscopy Facility at the Advanced Light Source [2] to study the half-metallic candidate material magnetite, (Fe_3O_4). The epitaxial films were grown at PNNL by evaporation in an O rich atmosphere onto MgO (100) substrates with precise control of gas flow and substrate temperature. Their structural properties were characterised in-situ by XPS and LEED and shown to be comparable to surfaces obtained from in-situ cleaving of bulk single crystals. After growth and characterisation the samples were transferred ex-situ to the ALS (total exposure time to atmosphere during sample transfer was approximately 5 minutes). Analysis of the ex-situ transferred samples at the ALS showed initial contamination levels of some 50%. By conducting spin-resolved photoemission measurements on these "as-received" samples we have demonstrated that cleaning by standard techniques such as ion bombardment will result in the loss of their spin polarization within minutes (figure 2). However our ability to perform spin resolved experiments at higher photon energies than is possible most other facilities, (as a direct result of the high brightness of the 3rd generation synchrotron source), has enabled us to successfully study the near Fermi edge polarization of the "as received" samples without having to resort further to such potentially destructive cleaning techniques. By measuring polarization as a function of emission angle and photon energy, and combining these measurements with a substrate overlayer model, we have been able to extract the underlying polarization of the bulk material and have demonstrated that it is significantly higher than the 30% initially observed in the "as-received" samples, and may indeed be up to 100%. Furthermore, our spin resolved spectra demonstrate close agreement with simulated spectra derived from theoretical one electron density of states calculations [3]. Further experiments are in progress.

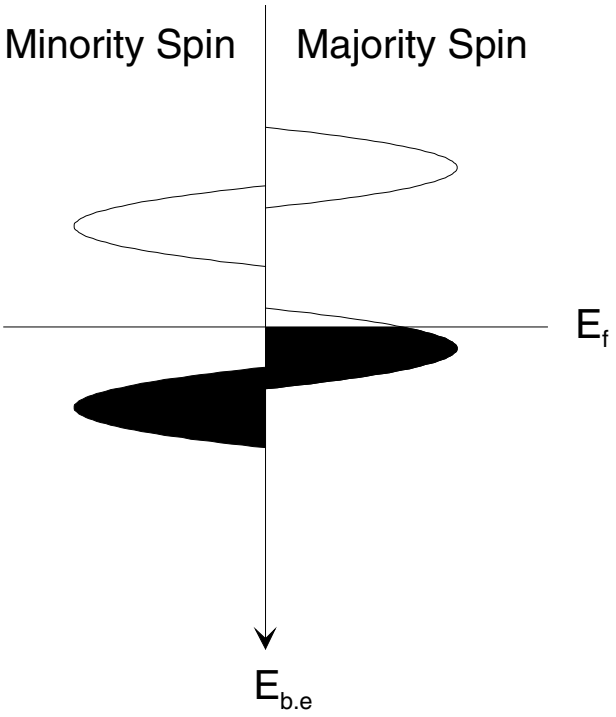
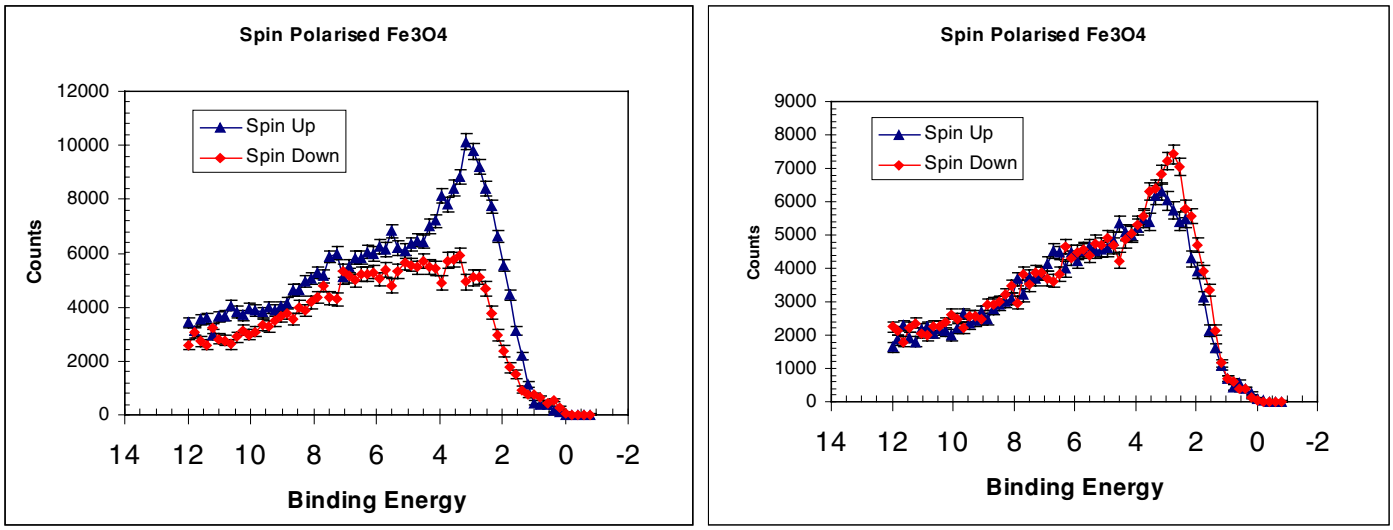


Fig. 1. Schematic band structure of a hypothetical half metal showing the co-existence of metallic and insulating characteristics in the majority and minority density of states.



(a) **(b)**

Fig. 2. Spin polarized valence band spectra of Fe3O4 (a) as received and (b) after 5 minutes sputtering with Ne ions demonstrating almost complete loss of polarisation

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